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ABSTRACT

Multiple linear regressions were employed to determine the relative contributions of cognitive and affective variables accounting for variance in college students' achievement and amount of time taken to complete a self-paced, individualized course. Study habits and attitudes (SSHA) made greater relative contributions to explaining total course achievement than cognitive variables. Cognitive variables (GPA and ACT) accounted for achievement variance under criterion-referenced conditions, and affective variables (SSHA and 16PF) accounted for achievement variance under norm-referenced conditions within the course. Time, which was inversely related to achievement, was explained best by college GPA and personality variables. Cross-validation of predictive equations for achievement and time in a subsequent sample was unsuccessful. (Author)

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The Prediction of Achievement and Time Spent in Instruction in a Self-paced Individualized Course

Thomas E. Franklin *

Multiple linear regressions were employed to determine the relative contributions of cognitive and affective variables accounting for variance in college students' achievement and amount of time taken to complete a self-paced, individualized course. (N=77)

Study habits and attitudes (SSHA) made greater relative contributions to explaining total course achievement than cognitive variables. Cognitive variables (GPA and ACT) accounted for achievement variance under criterion-referenced conditions, and affective variables (SSHA and 16PF) accounted for achievement variance under norm-referenced conditions within the course. Time, which was inversely related to achievement, was best explained by college GPA and personality variables.

Cross-validation of predictive equations for achievement and time in a subsequent sample was unsuccessful. (N=43)

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INTRODUCTION

A voluminous body of research literature has attested to the fact that the prediction of college success by traditional, intellectual kinds of variables can be substantially improved by employing affective, non-intellectual variables. Furthermore, in specialized, innovative college courses, variables other than conventional academic variables might be expected to make substantial contributions to a student's success or failure. In fact, Bloom (1971), co-founder of the innovative mastery strategy for learning, has suggested that whether the student will be able to successfully or unsuccessfully complete a learning task depends not only on the extent to which that student possesses the cognitive and affective characteristics demanded by the task itself, but also on the extent to which that student possesses the characteristics demanded by the manner in which the task is taught.

Therefore, this study was directed toward discerning the cognitive and affective variables which contributed to students' success in an innovative mastery-type college program where students were expected to pace themselves in instruction offered by means of closed circuit television programs, audio tapes, slide-tapes, and study guides. Furthermore, after reliably discerning the variables contributing to student success in the self-instructional course, this study was directed toward the utility of employing those variables for making practical decisions regarding selection of students for course admissions.

To accomplish these objectives, multiple linear regressions were employed in this study to address the following issues: (1) To identify and discern the relative contributions of cognitive, affective, and demographic variables accounting for individual differences in academic achievement and the time taken to complete instruction in a self-paced individualized college course in human growth and development. (2) To compare the independent variables accounting for achievement variability in criterion-referenced and norm referenced instructional conditions within the self-paced course, and in general college achievement (GPA). (3) To quantify

the independent variables making significant relative contributions to variability in self-paced achievement and the time spent in instruction, and thereby, construct linear regression equations for the prediction of those criteria in subsequent samples. And, (4) To employ those predictive equations with a separate sample of self-paced students to determine the predictive validity of the regression equations and, given this validity, to investigate the probabilistic use of regression equations as possible decision-making devices appropriate to courses utilizing a mastery strategy. If reliable predictive equations could be constructed and cross-validated on a subsequent sample, then those equations could be subjected to a z score formula to determine the probability of a student reaching an established achievement criterion within specified time limits.

Explored Relationships

Following directly from the preceding rationale and purposes of this study, the following relationships were explored:

1) The relationships among (a) the cognitive variables, previous academic performance and academic aptitude, (b) the demographic variables, sex, age, number of credit hours being taken, and semesters attended in college, and (c) the affective variables, study habits and attitudes, achievement motivation, locus of control, and personality, in accounting for individual differences in academic achievement and time spent to complete instruction in an individualized, self-paced course were examined.

   It was expected that cognitive variables would account for the largest proportions of variance in achievement and time spent in the course, relative to affective variables and demographic variables. However, affective variables were expected to substantially improve multiple correlations between cognitive variables and course achievement and time.

2) The relative contributions of affective and cognitive variables in accounting for variability in norm-referenced and criterion-referenced educational conditions within the course were explored.

   Individual differences related to objective, criterion-referenced academic success were expected to be differentiated from

individual differences related to subjective, norm-referenced academic success. Individual differences related to academic success in the self-paced course were expected to be differentiated from individual differences related to general academic success in college.

3) The utility and validity of employing linear regression equations, developed on the basis of students' characteristics in one sample, with students in a different sample to predict measures of academic success in the self-paced course, were explored.

It was expected that the multiple correlations between cognitive and affective variables and achievement and time spent in learning in the self-paced course could be reliably cross-validated with a second sample of self-paced students.

4) The efficacy of the probabilistic use of regression equations as opposed to "point" predictions by those equations, for making selective instructional decisions was explored.

It was expected that the relative contributions of cognitive and affective variables related to self-paced achievement and time spent in learning could be quantified and employed in linear predictive equations, which could be reliably cross-validated, to ascertain the probability that a self-paced student, with selected characteristics, could achieve an established level of mastery within specified periods of time.

PROCEDURES

Subjects

One-hundred and twenty volunteer undergraduates enrolled in the self-paced course "Human Growth and Development" offered by the Educational Psychology Department, West Virginia University, participated in this study. Although 217 of the 283 students enrolled in this course volunteered for the study, data collection for some predictor variables was incomplete for 97 students. Therefore, the sample size was reduced to 120 students for whom there was complete information for data analysis. These 120 students were randomly assigned to a normative sample (N=77) and a cross-validational sample (N=43).

Course Design

The Human Growth and Development course utilized in this study was the second part of a two course sequence in educational psychology required of undergraduate education majors. The course was self-instructional and was offered in a multi-media learning center.

Course content was individualized and presented by means of television, audio tapes, slide-tapes, program notes, and study guides. Educational objectives were established for each of the four units in the course. With the exception of the first class, students were expected to pace themselves through the course.

Final course grades were contingent on eight objective, criterion-referenced unit tests, norm-referenced scores on two written assignments, and attendance at four optional group discussions. Optional test re-takes on three alternate test forms per unit were available. Students were allowed to go backward or forward in the course sequence to improve test scores. Written assignments could be re-submitted at any time to improve students' grades. Although no level of mastery was established for students to attain, at their request students were informed of their level of achievement relative to established criteria for five letter grades. Therefore, students were expected to monitor their level of achievement throughout the four course units in order to achieve to their own

satisfaction in terms of a final course grade. In effect, each student could establish his own level of mastery. Tutorial assistance was available on request.

Data Collection

With four weeks remaining in the semester, students came, at their own convenience, to a room adjoining the learning center to take the test battery used for the collection of data on the predictor variables. Over a ten day period all volunteers completed the test battery. Since the test battery and all the instruments therein had separate instructions, students could work at their own pace. Students generally took from one hour to one and one-half hours to complete all instruments in the test battery booklet.

The testing battery consisted of a student consent form, the Holmes and Tyler (1968) self-report ranking instrument for achievement motivation which provided three separate need achievement scores, Rotter's Internal-External Attitude Survey (1966), Brown and Holtzman's Survey of Study Habits and Attitudes (Form C, 1953) which provided seven scale-scores, and Cattell's 16 Personality Factor Questionnaire, Form C (1969). All subjects received the test battery with the instruments arranged in this order.

The student consent form, which granted the student's permission to have their ACT scores (four sub-scale scores and a composite score) and college grade point averages retrieved, also contained a demographic data sheet. This instrument requested the following information of the students: Sex, age, semester in college (a total of all semesters at all colleges), the number of credit hours taken during that current semester, and estimated high school grade point average on a four point scale (a cognitive variable).

Counting each of the various scale-scores separately, data was collected for 38 predictor variables in the general categories of demographic, cognitive and affective variables.

Data collection for the criterion measures, achievement and time spent in learning, was accomplished after all students had completed the individualized course of instruction. Total achievement in the

course was defined as the additive total of the eight objectively scored unit test scores (two per unit), and the norm-referenced subjectively graded, two written assignment scores and five discussion attendance scores. Objective achievement was defined as the total of the eight unit test scores, and subjective achievement was defined as the total for discussion attendance scores and written assignment scores.

Time spent in instruction was operationally defined as the number of days students spent completing the course to their own satisfaction. This total number of days represented the additive total of the number of days it took the student to complete each of the four units. Days spent completing each unit was computed by subtracting the last julian calendar date on which the student was given a grade in that unit from the earliest recorded date for that unit. Since students could go forward or backward in the course sequence to improve grades, some overlap in days across units was possible.

Statistical Procedures

The raw scores for each measure for predictor variables and criterion variables were converted to normally distributed, standardized z scores with a mean of 0 and a standard deviation of 1. For ordinary predictive uses, normality of all distributions is not needed. No matter what sort of distribution the raw scores have, it still remains true that the predictive equations constructed by these raw scores offer the best prediction among all possible linear equations using the same variables. However, standardized z scores have been employed because standardized scores make interpretation of test results easier, and the procedure is essential in computing the probability of regression equations (Tatsuoka, 1969), a statistical method employed in this study.

Judicious selection of predictor variables for inclusion into multiple linear regression equations predicting the criterion measures, achievement and time spent in learning, for students in the normative sample was accomplished by means of stepwise multiple regressions. The proportion of vari bility in actual criterion scores (R^2) that was accounted for by its linear regression on the predictors in the normative sample is subject to some decrease, or shrinkage, in subsequent samples, which becomes greater as the number of predictor variables increases. Therefore,

judicious selection of variables accounting for variability in criterion measures was considered essential. Three different stepwise regression techniques were employed for selection of independent variables accounting for significant proportions of the variability in objective and subjective and total achievement, and in time spent in learning. These stepwise regression procedures either added, or dropped, predictor variables from the regression equation one at a time, provided that their addition, or deletion, resulted in a statistically significant increment in the amount of variability that could be accounted for in the criterion measure ($\alpha = .05$). In other words, these procedures revealed which variables, or combinations of variables, accounted for explainable variance in the dependent measures, with the criterion for inclusion of predictor variables into the regression equations being statistical significance with a $p < .05$ level of confidence.

The means, standard deviations, and correlations, in z score form, of those variables selected by stepwise regression techniques were employed in linear normal equations to determine the constants for the multiple regression equations predicting each of the criterion measures for the normative sample. The basic rationale for constructing multiple regression equations was to determine constants in such a way that the sum of squared deviations between predicted and actual criteria were as small as possible. In other words, the basic rationale was to choose constants in such a way that residual error was minimized. For example, if the stepwise regression techniques employed had found that course achievement (Y) could best be predicted from students' college grade point averages (X_1) and achievement motivation scores (X_2), then the intercorrelations of these variables would be used in normal equations to determine the constants (a, b_1, and b_2) which satisfied the multiple regression equation:

$$Y' = a + b_1X_1 + b_2X_2$$

Y' is an estimate of a mean. It is an estimate of the mean Y, the actual criterion score of all individuals with a given combination of X_1 and X_2 scores. Equations of this type were constructed for prediction of each of the criterion measures used in this study.

After having constructed the multiple regression equations, the predictive efficiency of the equations was assessed. The first technique

used to determine how good a job the equations did at predicting criterion measures was computation of the multiple correlation coefficient (R) for each predictive equation. The multiple correlation coefficient was nothing more than a regular product-moment correlation between Y and Y', the actual and predicted criterion scores. The higher the multiple correlation coefficient (R), the more efficient the predictive equation.

The square of R indicated the proportion of variability in Y that was accounted for by its linear regression on the predictors in the normative sample. Since R^2 referred to the proportion of variance accounted for in the criterion for the particular sample used in constructing the regression equations, cross-validation of the regression equations on an independent sample gave a more accurate estimate of the efficiency of actual predictions by the equation than did R. Therefore, the predictive equations developed from students' scores in the normative sample in this study were cross-validated against the students' scores in the cross-validational sample. The regression equations constructed on the basis of the normative sample were used to predict the criterion scores for each member of the cross-validational sample. Validational subjects, therefore, had an actual criterion score (Y) and a predicted criterion score (Y') for each dependent measure. An ordinary product-moment correlation coefficient between Y and Y' in the cross-validational sample, for each criterion measure, called a cross-validation multiple R (Rc), was computed. The magnitude of Rc for each criterion reflected the predictive efficiency of that regression equation.

Furthermore, the approximate probability that an individual with the selected combination of predictor scores (college GPA and achievement motivation scores for example) would reach an established criterion was computed. Using the predictive equation for achievement, criteria were established at the mastery level for the course grades of "A" and "B". After having computed the mean predicted criterion score, Y', for the particular combination of predictor scores employed in the predictive equation, the standard deviation for the sample (the standard error of estimate) was computed for inclusion into the Z-value procedure:

$$Z = \frac{Y^{\star}(\text{criterion or mastery level}) - Y'(\text{predicted criterion})}{S\ y/x\ (\text{standard error of estimate})}$$

This equation solved for the probability that a student with a given predicted criterion score (Y') will earn an established mastery level criterion, such as an "A" grade in the course (Tatsuoka, 1969). In other words, testing the probability of a student achieving the "A" criterion by means of the predictive equation (Y') was asking, "What are the chances that this individual will succeed in individualized instruction?"

Also, a factor analysis was computed to help discern the relationships among variables in this study which were related to academic success. The purpose of the factor analysis was to identify factors, or constructs, representing academic success. The results of the factor analysis were to be subjectively compared to linear regression findings to validate the definitions of classes, or clusters, of variables reflecting success in the self-instructional course.

RESULTS

Total Achievement

The Stepwise Multiple Regression procedure which included all 38 predictor variables in accounting for the total proportion of the variance in the total achievement criterion indicated that 72% of that variance could be explained (R^2 = .7180).

The best one-variable model accounting for variance in total achievement included only the predictor variable college GPA (R^2 = .4189). However, a six variable model ascertained from the regression procedure, which accounted for 79% of the explainable variance (R^2 = .5678) represented a significant increment in R from the one-variable model, using an F test for the increment in R (McNemar, 1969) (F = 4.62; df = 5, 75; p<.05). Of all the models examined by regression techniques, this six-variable model represented the greatest amount of variance in the criterion, total achievement, which could be explained, with the most efficient use of predictors, in terms of number of independent variables employed. These six variables, in combination, each made a significant contribution to explaining variance in the criterion at the .01 level of confidence. The analysis of variance for this multiple linear regression is presented in Table 1.

TABLE 1

Analysis of Variance for the Stepwise Regression on Total Achievement: The Six-Variable Model

Source	df	MS	F	p	R^2
Regression	6	28394.38	15.33	.0001	.5678
Error	70	1852.80			
Total	76				

Source	df	Partial SS	F
College GPA	1	47340.31	25.55**
SSHA Study Attitude	1	31019.73	16.74**
SSHA Study Orientation	1	25461.31	13.74**
ACT Composite	1	18004.07	9.72**
ACT English	1	14401.34	7.77**
16PF Q2 (self-sufficiency)	1	13224.34	7.14**

** p<.01

Because the six-variable model accounted for the largest R^2 with maximal efficiency for prediction of total achievement, those six variables were selected for inclusion into the linear equation designed to predict the criterion in subsequent samples. Therefore, the intercorrelations between predictors and the criterion were used in normal equations to determine the constants a, b, b_2, b_3, b_4, b_5, and b_6, which satisfied the multiple linear regression equation:

$$Y' = a + b_1X_1 + b_2X_2 + \ldots b_6X_6$$

This equation represented the equation of the plane for Y', the equation for the best-fitting line representing total achievement. Y' in this equation represented the predicted criterion, total achievement. The b values in the equation represented the slopes of the six planes, b_1 the slope which the plane made with the X_1 axis, b_2 the slope with regard to the X_2 axis, and so on. The value of "a" in the equation was the value of Y where the plane cut the y axis.

Because raw scores were converted to z scores, which made the different independent variables comparable, the linear equation was transformed to read:

$$Z_y{}^1 = B_1z_1 + B_2z_2 + \ldots B_6z_6$$

Since deviation scores were used to convert raw scores to z scores, the value of "a" in the raw score formula became equal to zero in the standard score form. In deviation score form, the plane for Y' cuts the y axis at the origin and "a" = 0. The task then was to determine the values of the beta coefficients (B_1 - B_6), so as to have the best estimate of Z_y, total achievement. Since standard scores were employed, certain properties of those scores could be capitalized on, namely, that the sum of their scores divided by N was unity, and any sum of their cross products divided by N was the correlation between the two variables involved in the cross products (McNemar, 1969, p. 191). The normal equations in standard score form, where r_{12} was the correlation between predictor variables X_1 (z_1) and X_2 (z_2), respectively, with Y (z_y) follow:

$$B_1 + r_{12}B_2 + r_{13}B_3 + r_{14}B_4 + r_{15}B_5 + r_{16}B_6 = r_{1y}$$

$$r_{21}B_1 + B_2 + r_{23}B_3 + r_{24}B_4 + r_{25}B_5 + r_{26}B_6 = r_{2y}$$

.

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$$r_{61}B_1 + r_{62}B_2 + r_{63}B_3 + r_{64}B_4 + r_{65}B_5 + B_6 = r_{6y}$$

By substituting actual correlations into the standard score normal equations (above) and solving the linear equations simultaneously, seeking values for the unknown beta weights (B's), the following coefficients were calculated:

B_1 for College GPA = .5120
B_2 for SSHA-SA = -.7495
B_3 for SSHA-SO = .6811
B_4 for ACT Composite = .3713
B_5 for ACT English = -.3110
B_6 for 16PFQ2 = .2225

These constants were then substituted into the linear equation for the prediction of total achievement from the six independent measures:

Predicted total achievement (Z_y') = (.5120) (College GPA $_{z1}$) + (-.7495) (SSHA-SA_{z2}) + (.6811) (SSHA-SO_{z3}) + (.3713) (ACT Composite $_{z4}$) + (-.3110) (ACT $English_{z5}$) + (.2225) ($16PFQ2_{z6}$)

Ranked according to their relative importance in predicting total achievement, those variables which were significantly positively related to the criterion were SSHA Study Orientation (a composite measure of study habits and attitudes), College GPA, ACT composite score, and 16PF factor Q2 (self-sufficiency).

It should be noted that although college grade point average was consistently observed to account for significant proportions of the variability in total achievement, the composite SSHA score exceeded college GPA in importance for predicting total achievement in this predictive model. Since all raw scores were converted to standard scores and the predictive equation was developed by establishing standardized regression weights, or beta coefficients, the independent variables employed were

comparable in terms of units of measurement, and the calculated beta values could be interpreted as representing the relative contributions to those independent variables in predicting total achievement. The relative contribution of SSHA Study Attitudes exceeded SSHA Study Orientation and college GPA in importance for predicting total achievement. However, this variable maintained a significant negative relationship with the criterion, as did ACT English scores. Each of these two negatively related predictors of the criterion individually resulted in negative slopes for the planes they made with the criterion. Nevertheless, when examined collectively with the other four predictors, the best fitting line representing the regression of total achievement on the six predictors was obtained.

The accuracy of the prediction of total achievement by this combination of variables was ascertained by examination of the error term for the equation, called the standard error of estimate. The standard error of estimate was calculated by the formula:

$$S_{zy.z_1z_2z_3z_4z_5z_6} = 1-(B_1r_yz_1+B_2r_yz_2+B_3r_yz_3+B_4r_yz_4+B_5r_yz_5+B_6r_yz_6)$$

The standard error of estimate for the predictive equation ($S_{zy.z_1z_2z_3z_4z_5z_6}$) was .6574 in standard score form. The variance of the errors equaled .4322, which was analogous to the sum of the squares for the errors (actual criterion minus predicted criterion, zy - zy') divided by N.

Some indication of the predictive efficiency of this linear equation for total achievement was given by computation of the multiple correlation coefficient, or multiple R ($R_{zy.z_1z_2z_3z_4z_5z_6}$). The multiple correlation coefficient represented the correlation between the actual criterion (ZY) and the best estimate of that criterion (z_y') from a knowledge of the predictors (z_1, z_2, z_3, z_4, z_5, and z_6). The actual criterion was considered to consist of basically two parts, that which could be estimated from the predictive equation Zy', and residual error, the standard error of estimate. The multiple R in terms of interpretation, represented a regular product-moment correlation between the actual criterion and the estimated criterion plus residual error. The multiple correlation coefficient concerning the predictive equation for total achievement was calculated at R = .7535. The square of R

indicated the proportion of variability in total achievement that was accounted for by its linear regression on these predictors in the normative sample. R^2 equalled .5678, which meant that 57% of the variability in total achievement could be attributed to the individual differences in the predictor variables among members of the normative sample. The multiple correlation coefficient, R, and the proportion of the variance accounted for, R^2, were biased estimates. They referred only to what was true of the sample used in constructing the regression equation. There will almost always be some decrease in the corresponding proportion of the variance explained for subsequent samples. The amount of this decrease, called shrinkage, becomes greater as the number of predictor variables increases, or as the normative sample size decreases. An unbiased estimate of R and R^2, estimating the proportion of the variability in the criterion likely to be accounted for in subsequent samples, was computed. The formula for the multiple-R corrected for shrinkage was:

$$R' = 1 - \frac{N-1}{N-p-1}(1 - R^2)$$

In this formula, N = the normative sample size, p = the number of predictors employed, and R^2 was the proportion of the variance explained within the normative sample. The multiple-R corrected for shrinkage for predicting total achievement from the six predictors was $R' = .7286$. The unbiased estimate of R^2, was $R^{2'} = .5309$. That is, in subsequent samples, the proportion of the variance in total achievement likely to be explained by these six predictors was about 53%, rather than 56% as computed in the biased estimate.

To verify the predictive validity of linear regression equations developed on the basis of student characteristics in the normative sample (N=77), those equations were used to predict the dependent measure of achievement for students in a different sample (N=43). The cross-validation sample (N=43) had been randomly drawn from the original 120 students for whom complete predictor information existed. To insure the homogeneity of the variances of the two related samples, on each independent measure, homogeneity tests were computed. With $\alpha = .05$ in two-tailed t tests for the homogeneity of related (correlated) variances, no

differences between the normative and the cross-validational samples were ascertained. Therefore, the linear equations selected to predict the criteria of course success, with standardized beta weights for each of the independent variables accounting for significant proportions of the variances in the criteria, were actually used to predict the dependent variable, in z score form, for cross-validational students. Each student in the cross-validational sample, therefore, had a predicted criterion score and an actual criterion score, both in z score form. Zero-order correlations were then computed to determine the relationship between students' predicted criterion and actual criterion. If the magnitude of this cross-validation multiple R (Rc) was reasonably close to R', the normative multiple R corrected for shrinkage, then the predictive validity of the linear equations would be verified. Verification of the predictive validity of those equations would indicate that the equations could be confidently employed to predict academic success in subsequent samples. Given this confidence, the probabalistic use of the regression equations to predict established levels of success or mastery could be employed. This probabalistic function could then be implemented in terms of a decision making model based on the probability that a student could achieve a given level of mastery within a specified period of time. However, the zero-order correlation between actual and predicted total achievement, the cross-validation multiple R, Rc, was .3564 ($p>.05$), which did not approach the magnitude of R corrected for shrinkage, R'. Therefore, the validity of employing the six-variable linear equation for the prediction of total achievement in subsequent samples was not acceptable and did not warrant its adoption for decision-making purposes.

Objective Achievement

The selection of independent variables for inclusion into regression equations to predict objective achievement points earned in the course was accomplished in the same fashion as for the total achievement criterion, by means of Stepwise Regression techniques.

College GPA was the only independent variable selected which independently accounted for a significant proportion of the variance in objective achievement ($F = 54.79$; $df = 1, 75$; $p<.0001$; $R^2 = .42$).

When all 38 predictors were included in the regression, 69% of the variance in the criterion could be explained. College GPA (R^2 = .42), therefore, had accounted for 61% of the variance capable of being explained by this combination of independent measures.

However, a nine-variable model represented a significant increase in the proportion of the variance in objective achievement which could be explained by the one-variable model (F test for the increment in R; F = 3.07; df = 8, 75; $p<.05$; R^2 = .61). Ranked in order of their relative importance in explaining the criterion, the nine variables were ACT composite, college GPA, ACT english, SSHA teacher attitude, SSHA delay avoidance, sex, 16PFQ4 (relaxed), 16PFQ2 (self-sufficient), and Locus of Control. Only the locus of control variable was insignificant at the .05 level. Since sex was noted to be a significant predictor, separate regressions and predictive equations were computed for male and female students.

A ten-variable model ascertained by Stepwise regressions was the only model containing predictors which maintained significant relationships with objective achievement for female students, and which resulted in a significant increment to a one variable (college GPA) model. The increment in R from college GPA (R^2 = .43) to the ten-variable model (R^2 = .72) was significant at the .05 level (F = 4.18; df = 9, 75). Therefore, this ten-variable model for the objective achievement of female students, which accounted for 88% of the explainable variance for that criterion, was adopted for prediction purposes in the cross-validational sample. The regression of objective achievement on the ten predictors was significant at the .01 level of confidence (F = 11.87; df = 10, 47). The analysis of variance for this regression analysis is presented in Table 2.

TABLE 2

Analysis of Variance for the Stepwise Regression on Female Objective Achievement: The Ten-Variable Model

Source	df	MS	F	p	R^2
Regression	10	15302.21	11.87	.0001	.72
Error	47	1288.80			
Total	57				

Source	df	Partial SS	F
College GPA	1	55906.23	43.38**
ACT Social Science	1	13746.39	10.67**
SSHA-Study Attitudes	1	18949.61	14.70**
SSHA-Delay Avoidance	1	9993.62	7.75**
16PFQ2	1	7909.63	6.14**
16PFQ4	1	8958.26	6.95**
16PFB	1	6352.89	4.93*
ACT English	1	7256.11	5.63*
16PFQ3	1	7154.85	5.55*
16PFC	1	5731.81	4.45*

* $p < .05$
** $p < .01$

The equation for the best fitting line representing objective achievement of females in the normative sample assumed the form:

$$\text{Predicted objective achievement} = (B_1)(\text{College GPA}_{z1}) + (B_2)(\text{ACTSS}_{z2}) + (B_3)(\text{SSHA-SA}_{z3}) + (B_4)(\text{SSHA-DA}_{z4}) + (B_5)(16\text{PFQ2}_{z5}) + (B_6)(16\text{PFQ4}_{z6}) + (B_7)(16\text{PFB}_{z7}) + (B_8)(\text{ACT English}_{z8}) + (B_9)(16\text{PFQ3}_{z9}) + (B_{10})(16\text{PFC}_{z10})$$

In this equation, the B values were the standardized beta weights, in z score form, for each independent variable. These constant values were computed in the same fashion as for the total achievement criterion. Each B value represented the slope of the plane for objective achievement of females with the predictor that beta weight accompanied. The B values used for prediction of female students' objective achievement were:

$B_1 = .6813$ $B_6 = -.2221$
$B_2 = .3483$ $B_7 = .1792$
$B_3 = -.3796$ $B_8 = -.2645$
$B_4 = .2629$ $B_9 = -.2221$
$B_5 = .2173$ $B_{10} = .1869$

The ten variables ranked according to their relative contributions to predicting the criterion were college GPA, SSHA Study Attitudes (a combination of student's opinions of the teachers and their methods, and their approval of educational objectives and course requirements), ACT Social Science, ACT English, SSHA Delay Avoidance, 16PFQ4 (relaxed), 16PFQ3 (not conscientious), 16PFQ2 (self-sufficient), 16PFC (mature and stable), and 16PFB (fast learner).

The standard error of estimate, in standard score form, for this predictive equation for objective achievement of female students was .5325. The variance of errors (actual criterion - predicted criterion divided by N) was .2836 in z score form.

The multiple correlation coefficient, the correlation between actually earned objective achievement points and the best estimate of that criterion (the predicted criterion) was $R = .8464$ ($R^2 = .72$). An unbiased estimate of the multiple R, the multiple R corrected for shrinkage, was computed to give some insight into what might be expected of the predictive equation in subsequent samples. R' was calculated to be .6783. The proportion of the variance in objective achievement of females which was explained by the ten predictors, corrected for shrinkage, was $R^{2'} = .4601$.

The Stepwise Regressions for the selection of independent variables predictive of objective achievement for male students (N=19) indicated that a ten-variable model accounted for 99% of the variance in that criterion. This ten-variable model which contained the predictors, college GPA, Summed Nach, 16PF factor O, 16PF factor B, SSHA Delay Avoidance, SSHA Teacher Acceptance, 16PF factor Q2, 16PF factor L, 16PF factor G, and high school grade point average, was noted to account for a significant proportion of the variance in males' objective achievement ($F=110.39$; $df=10, 8$; $p<.01$) and to consist of variables which independently contributed to the explanation of variance in the criterion. The small sample size for this analysis made the findings highly questionable. Nevertheless, the ten-variable model represented the best available estimate of the variance explained by the predictors in this study. The analysis of variance for this predictive model for objective achievement of males in the normative sample is presented in Table 3.

TABLE 3

Analysis of Variance for the Regression for Objective Achievement of Males: The Ten Variable Model

Source	df	MS	F	p	R^2
Regression	10	2340.22	110.39	.0001	.9928
Error	8	21.20			
Total	18				

Source	df	Partial SS	F
College GPA	1	12666.14	597.52**
Summed Nach	1	4480.07	211.35**
16PFO (self-assured)	1	3803.89	179.45**
16PFB (intelligent)	1	4685.24	221.02**
SSHA-DA	1	2376.89	112.13**
SSHA-TA	1	2081.07	98.17**
16PFQ2 (self-sufficient)	1	1154.06	54.44**
16PFL (suspicious)	1	976.15	46.05**
16PFG (expedient)	1	351.58	16.59**
H.S. GPA	1	242.44	11.44**

**p<.01

Although the results of the regression of objective achievement for males on the ten predictors was considered to be of dubious value, because of the sample size, until it had been reliably cross-validated, the equation for the best fitting line representing that criterion, nevertheless, assumed the form:

$$\text{Predicted objective achievement for males} = (B_1)(\text{College GPA}_{z1}) + (B_2)(\text{Summed Nach}_{z2}) + (B_3)(16\text{PFO}_{z3}) + (B_4)(16\text{PFB}_{z4}) + (B_5)(\text{SSHA-DA}_{z5}) + (B_6)(\text{SSHA-TA}_{z6}) + (B_7)(16\text{PFQ2}_{z7}) + (B_8)(16\text{PFL}_{z8}) + (B_9)(16\text{PFG}_{z9}) + (B_{10})(\text{H.S. GPA}_{z10})$$

The standardized regression weights, B values, represented the slopes of the planes for objective achievement of males with each of the predictors. The B values used for prediction of objective achievement of male students were:

$B_1 = 1.1399$ $B_6 = .3571$
$B_2 = .5505$ $B_7 = .2894$
$B_3 = -.5375$ $B_8 = .2571$
$B_4 = -.6262$ $B_9 = -.1763$
$B_5 = -.5244$ $B_{10} = .1346$

The raw scores for the ten predictors in this equation for the objective achievement of males were converted to standardized z scores. Utilization of these standard z scores and standardized regression weights made the ten independent variables comparable in terms of unit of measurement, and the B values were interpreted as representing the relative contributions of the predictors in accounting for the variance in objective achievement of males.

Ranked according to their relative importance in predicting the criterion, the positively related independent variables were college GPA, the composite score for achievement motivation, SSHA teacher acceptance, 16PF factor L (interested in internal, mental life), and high school grade point average. The variables which maintained significant negative relationships with the criterion, ranked according to their relative importance, were 16PF factor B (slow to learn), 16PF factor O (free from anxiety), SSHA Delay Avoidance, 16PF factor Q2 (group dependence), and 16PF factor G (undependable, quitting). The collective plane for these ten variables in relation to objective achievement for males in the normative sample represented the best fitting line for that criterion.

The standard error of estimate for this question, in z score form, was S_z=.0849. The variance of the errors for this equation was S_z2=.0072. The multiple correlation coefficient, the estimated correlation between the actual criterion scores and the scores calculated by the predictive equation was R=.9964. R^2, the proportion of the variability in objective achievement for males in the normative sample accounted for by this combination of predictors, was, as already referenced, equal to .9928. Because of the small sample size employed in these analyses, however, the validity of these findings was left contingent on cross-validation of the predictive equation on a different sample. However, some indication of what proportion of the variance in males' objective achievement could be expected to be accounted for in a different sample was obtained by the multiple-R corrected for shrinkage. R' for objective achievement predicted from the 10 predictors was .9837, and $R^{2'}$=.9918.

While the regressions for objective achievement on the independent variables suggested that different equations should be developed for males and for females, the small sample of males (N=19) negated the use of that equation for predictive purposes. Those equations for objective achievement stratified by sex were useful in discerning the relative contributions of variables, but of little value for predictive purposes. Therefore, the linear regression equation for the objective achievement of all students was employed for cross-validation in the validation sample. That predictive equation assumed the form:

Predicted Objective Achievement = (.5348) (College GPA) + (-.1983) (16PFQ4) + (.1674) (16PFQ2) + (-.2845) (SSHA-TA) + (.2504) (SSHA-DA) + (.5377) (ACT composite) + (-.3608) (ACT English) + (.2152) (Sex) + (.1381) (Locus of Control)

On the basis of the normative sample, the proportion of the variance in objective achievement accounted for by the variables in this equation was R^2=.6081. The multiple correlation coefficient was R=.7798. R corrected for shrinkage was R'=.5555. The cross-validation multiple R was computed to be Rc=.3251 (p>.05). As was the case with total achievement, the magnitude of Rc did not approach the magnitide of R', and the utilization of this predictive equation for making practical decisions was abandoned.

Subjective Achievement

The Stepwise Regressions employed for the judicious selection of independent variables predictive of subjective achievement within the course indicated that all 38 predictors could account for only 46% of the variance in that criterion. While no one-variable model represented a significant proportion of the variance in subjective achievement, the two-variable model containing, in order of importance, 16PF factor H (timid, withdrawn) and SSHA Delay Avoidance did represent a significant proportion of the variance in the criterion (F=7.33; df=2, 74; p<.01; R^2=.1654). Of the explainable variance in subjective achievement (46%), these two variables could account for 36% of that variance.

However, a five-variable model containing the independent measures college GPA, 16PF factor H, high school GPA, hours taken that semester, and the Delay Avoidance scale of the SSHA was a model which was composed of predictors that all maintained significant relationships with the

criterion. These five variables, in combination with each other, could account for significant proportions of the variance in subjective achievement ($F=5.68$; $df=5, 71$; $p<.01$; $R^2=.2858$). Even though the five-variable model did not result in a significant increment in R^2 from the two variable model suggested by the Stepwise procedure, as tested by an F test for the increment in R ($F=3.56$; $df=3, 74$; $p>.05$), all of the variables contained in the model maintained significant relationships with the criterion, and this finding was expected to be reproduceable. None of the predictive models examined could result in a significant increment to the R produced by the two (affective) variable model. Nevertheless, the best predictive model in terms of accounting for the largest proportion of criterion variance, while using only significantly related predictors, was the five-variable model. This model could account for 62% of the variance capable of being explained in subjective achievement by the employed predictors in this study. Table 4 presents the analysis of variance for the regression of subjective achievement by the five variables.

TABLE 4

Analysis of Variance for the Regression on Subjective Achievement: The Five-Variable Model

Source	df	MS	F	p	R^2
Regression	5	1385.93	5.68	.0003	.2858
Error	71	243.84			
Total	76				

Source	df	Partial SS	F
16PFH (shy)	1	1759.75	7.22**
SSHA-DA	1	1190.06	4.88*
Hours taken	1	1665.46	6.83**
College GPA	1	2191.56	8.99**
H.S. GPA	1	1411.74	5.79*

*p<.05
**p<.01

The five independent variables representing the most efficient prediction of subjective achievement were employed in the linear equation for

the best fitting line representing that criterion, which assumed the form:

$$\text{Predicted Subjective Achievement} = (B_1)\ (16PFH_{z1}) + (B_2)\ (SSHA\text{-}DA_{z2}) + (B_3)\ (\text{Hours Taken}_{z3}) + (B_4)\ (\text{College GPA}) + (B_5)\ (\text{High School GPA})$$

In this equation, the B values were the standardized beta weights, in z score form, for each of the predictor variables. Each B value represented the slope of the plane for subjective achievement with the independent variable that regression weight accompanied. The B values used for the prediction of subjective achievement were:

$B_1 = -.2766$
$B_2 = .2369$
$B_3 = -.2877$
$B_4 = .4045$
$B_5 = -.3011$

In this equation both the B values and the students' scores for each of the five independent variables were converted to standardized z scores. This procedure made the independent variables comparable in terms of unit measurement, and the B values were interpreted as representing the relative contributions of the predictors in accounting for the variance in subjective achievement.

Given that these standardized regression weights could be interpreted in terms of the relative contributions of each independent measure in accounting for individual differences in subjective achievement, college GPA was observed to be the most important predictor of the criterion. The Delay Avoidance scale of the SSHA was also observed to be positively related to subjective achievement, but less influential in accounting for the explained variance in the criterion than college GPA. The other three predictor variables maintained significant negative relationships with the criterion. Ranked in order of their relative contributions to predicting subjective achievement, that is in terms of their magnitude, the variables were high school GPA, the number of credit hours taken that semester, the 16PF factor H (shy, withdrawn). The fact that shy, withdrawn students might not like to attend group discussions, and that students with a large course-load might not find time to attend group

discussions or put forth a lot of effort on written assignments was easy to understand. However, why good students in high school would allow their course grades to suffer because of rather traditional requirements was incongruent in terms of psychological meaning. An examination of the correlation matrix showed no relationship between high school GPA and subjective achievement. Nevertheless, in combination with the other variables in this predictive equation, high school GPA was heavily weighted in the negative direction.

The standard error of estimate for this equation representing the best fitting line for subjective achievement was S_z=.8451. This error, in z score form, was interpreted as being rather large, primarily due to the fact that a great deal of the variance in subjective achievement had been unexplained by the predictors employed. The variance of the errors for this equation was S_z^2=.7142. The multiple correlation coefficient, the correlation between actual and predicted subjective achievement scores for students in the normative sample, was R=.5346. The proportion of the variability in the criterion which could be accounted for by the five independent variables was, as already noted, R^2=.2858. A great deal of the variance in subjective achievement was not accounted for by the predictors employed in this study. Either those variables employed to predict this criterion did not maintain linear relationships to subjective achievement, or different variables need to be examined. Nevertheless, these five variables represented the most accurate, efficient prediction of the criterion available, and this model was used to predict subjective achievement of students in the cross-validational sample. The multiple R corrected for shrinkage was .2461, and $R^{2\prime}$=.0606. The cross-validational multiple R, Rc, was calculated to be .1249 ($p>.05$). This finding negated the utility and validity of predicting subjective achievement by this model.

A separate Stepwise Regression for subjective achievement employed with the cross-validational sample (N=43) indicated that affective variables were the only ones accounting for criterion variance in that sample. A five-variable model containing the variables Locus of Control, 16PFQ3 (self-controlled), 16PFN (calculating), SSHA Educational Acceptance, and 16PFE (self-assured), (listed in order of relative importance) was

found to account for 41% of the subjective achievement variance in that sample ($F=5.20$; $df=5, 37$; $p<.01$; $R^2=.4128$). Each of these affective variables were noted to be independently significantly related to the criterion.

The Relative Contributions of Cognitive and Affective Variables Accounting for Variability in College Grade Point Averages

Of all the independent variables observed to relate to academic achievement in the self-paced course, college grade point average was the most prevalent. In fact, college grade point average was observed to account for significant proportions of the variance in achievement for every linear model adopted for predictive purposes. In the Stepwise regressions, college GPA represented the best single predictor of total achievement, objective achievement for females, and subjective achievement in the self-paced course. The objective achievement of males was the only achievement criterion for which college GPA did not represent the best single predictor. Therefore, to identify the cognitive and affective variables contributing to individual differences in college GPA, assumed to be a norm-referenced measure of academic success, Stepwise regressions were computed.

The Stepwise regression for college GPA on the independent variables indicated that the cognitive variables, high school grade point average and ACT composite scores, and the affective variables, 16PFA and the composite achievement motivation scores, accounted for significant proportions of the variance in college GPA ($F=29.77$; $df=4, 72$; $p<.01$; $R^2=.6232$). Both independently of each other and collectively these variables could explain significant proportions of the variance in GPA with $\alpha=.01$. Both of the cognitive variables maintained positive relationships with the criterion, and these results were interpreted as being congruent with previous research endeavors. Achievement motivation also maintained a positive relationship with college GPA which was congruent with previous research. Sixteen PF factor A maintained a negative correlation with college GPA. This factor, which had also been noted to account for significant proportions of the variability in achievement in the self-paced course, was interpreted as implying that aloof persons, who like working alone, exhibit higher academic achievement than warm, outgoing, sociable persons.

In regard to the relative contributions of each of those indicants of academic success in college, as assessed by their standard regression weights for the four-variable combination, high school GPA made the greatest contribution, closely followed by ACT composite scores, achievement motivation, and then the personality variable. All 38 of the predictors could account for 77% of the variance in college GPA. These four significant variables represented 80% of that explainable variance.

Time Spent in Instruction

The criterion, time spent in instruction, defined as the total number of days it took a student to complete an instructional unit, summed over the four units in the course, was examined by the Stepwise Regression techniques to discover which independent variables could account for the variance in that criterion.

The Stepwise regression procedure for the regression of time spent in learning on the independent variables indicated that the two predictive measures, the English sub-scale of the ACT, and the Peer need achievement scale, accounted for significant proportions of the varaince in the criterion both independently of each other, in the Sequential sums of squares, and in combination with each other, in the Partial sums of squares ($F=7.94$; $df=2, 74$; $p<.01$; $R^2=.1766$). Both of these predictive measures maintained significant negative, inverse relationships with the criterion, time spent in instruction. It is important to note that time spent was negatively correlated with students' total achievement scores ($r=-.28$, $p<.05$). The longer it took students to complete the course, the poorer their achievement. Therefore, it was not too surprising to find language aptitide inversely related to time ($r=-.34$, $p<.01$). The fact that peer Nach was negatively related to the amount of time spent ($r=-.23$, $p<.05$) suggested that although students were self-paced, they were aware of the progress of their peers in the course.

A five-variable model containing the predictors, college grade point average, locus of control, 16 PF factor Q3 (self-controlled), 16PF factor A (aloof, likes working alone), and 16PF factor E (dominant, self-assured) accounted for 29.53% of the variance in time. This was 55.85% of the variance in time capable of being explained by the predictors used in this study (52.87%). The five variables could account for significant

proportions of the variance in time either independently or in combination with each other ($F=5.95$; $df=5, 71$; $p<.01$; $R^2=.2953$). This five-variable model represented a substantial increase in the R^2 for the two-variable model ascertained by the Stepwise procedure. However, the increment from $R^2=.1766$ to $R^2=.2953$ for the five-variable model was found to be not significant by an F test for the increment in R ($F=3.56$; $df=3, 74$; $p>.05$). None of the models examined resulted in significant increments to the R obtained in the two-variable model. Nevertheless, the five-variable model did account for a relatively large proportion of the variance in time while employing only significantly related variables. The analysis of variance for the five-variable regression model for time spent in instruction is presented in Table 5.

TABLE 5

Analysis of Variance for the Regression on Time Spent in Learning: The Five-Variable Model

Source	df	MS	F	p	R^2
Regression	5	4187.03	5.95	.0003	.2953
Error	71	703.60			
Total	76				

Source	df	Partial SS	F
College GPA	1	13602.58	19.33**
16PFQ3 (controlled)	1	5430.94	7.72**
16PFA (aloof)	1	4089.29	6.84*
16PFE (assertive)	1	3727.21	5.30*
Locus of Control	1	2880.18	4.09*

*p<.05
**p<.01

Given these five variables, the equation for the best fitting line representing time spent in instruction assumed the form:

$$\text{Predicted time spent in instruction} = (B_1)(\text{College GPA}_{z1}) + (B_2)(16\text{PFQ3}_{z2}) + (B_3)(16\text{PFA}_{z3}) + (B_4)(16\text{PFE}_{z4}) + (B_5)(\text{Locus of Control}_{z5})$$

Each of the standardized beta weights, in z score form, presented in this equation, represented the slope of the plane for time spent in instruction with the independent variable that beta weight accompanied.

The beta values used for prediction of time spent in instruction in this equation were:

$$B_1 = -.4684$$
$$B_2 = .3042$$
$$B_3 = -.2740$$
$$B_4 = .2351$$
$$B_5 = .2118$$

The raw scores for the five predictors in this linear equation were converted to standardized z scores. Utilization of these standard z scores and standardized regression weights made the five independent variables comparable in terms of unit of measurement, and the B values were interpreted as representing the relative contributions of the predictors in accounting for the variance in time spent in instruction by students in the normative sample.

Ranked according to their relative importance in predicting the criterion of time, the positively related independent variables were 16PF factor Q3 (self-controlled) and 16PF factor E (dominant, self-assured). The variables which maintained significant negative relationships with the criterion, ranked according to their relative importance, or magnitide, were college grade point average, 16PF factor A (aloof, likes working alone), and Locus of Control (internality meant more time spent). These variables taken collectively represented the best fitting line for the amount of time a student spent in instruction. These personality descriptions of students who spent the most time in instruction might logically be interpreted as descriptions of successful, conscientious students. However, time was significantly related to academic achievement in the course in a negative direction. These seemingly positive personality descriptions represented students who spent more time completing the course, but generally achieved less. Internality on the locus of control instrument purports to be related to high academic achievement. However, students in this sample who exhibited internality spent more time, but achieved relatively less than students who spent less time. Again, this contradiction to expectations suggested that traditionally good students, who would be expected to thrive in self-paced instruction, spend a longer time completing the course than the students who received the best grades.

The standard error of estimate for the predictive equation for time, in z score form, was S_z=.8395. The variance of the errors for this equation was S_z^2=.7047. These error terms were considered to be rather large, primarily because a large portion of the variance in time spent in instruction was unexplained. The multiple correlation coeffieient was R=.5434. The proportion of the variance in time spent in instruction which could be accounted for by these five independent variables was R^2=.2953. The variables employed in this study were expected to account for a larger portion of the variance in time than was explained. Although 34 of the variables could have been used to predict time, with an R=.7271; R^2=.5287, the probability of reproducing those results on a similar sample was considered to be too low for practical predictive purposes. In all likelihood, time maintained non-linear relationships to the variables employed in this study. This, of course, awaits validation. The five-variable model employed to predict time spent in instruction represented the most efficient, reliable prediction of that criterion by linear means. Some indication of what was to be expected in cross-validation, in terms of proportion of the variance to be explained, was gleaned from the computation of the multiple-R corrected for shrinkage, R'=.2562, R^2'=.0656.

The actual cross-validation with the validational sample resulted in Rc=.1249 ($p>.05$). For predictive purposes, this linear equation for time spent in instruction did not warrant confidence. It was interesting to note, however, that in Stepwise Regressions for this criterion in the cross-validational sample (N=43), cognitive variables were of negligible importance. In fact, the most efficient model for this sample which accounted for 40% of the variability in time, contained only the affective variables 16PFQ3, 16PFQ4, 16PFC, Locus on Control, SSHA Delay Avoidance, and 16PFO (F=4.05; df=6, 36; $p<.01$; R^2=.4033). The relative importance of these affective variables in accounting for time spent in the validational sample is best expressed through their standardized beta coefficients:

SSHA - Delay Avoidance	-.3558
Locus of Control	-.3580
16PFQ3 (controlled)	-.4463
16PFC (emotionally stable)	.3702
16PFQ4 (relaxed)	.3815
16PFO (self-assured)	-.2495

Factor Analysis of the Explored Variables

To help understand the relationships among the variables in this study which related to academic success, a factor analysis was computed. The purpose of the factor analysis was to identify factors, or constructs, representing academic success. The findings of the factor analysis were to be subjectively compared to linear regression findings to validate definitions of classes, or clusters, of variables reflecting success in the self-instructional course.

With this purpose, a principle components factor analysis was calculated. All predictive and criterion variables were inter-correlated, and the principle components method, with positive eigenvalues, was used for computation of the components. The squared multiple correlations were entered in the main diagonal of the matrix and the components rotated to orthogonal simple structure by means of the varimax method, using Kaiser's criteria, minimum eigenvalue (1), for extracting factors (Kaiser, 1958).

The resulting rotated factor matrix suggested that the total variance among all variables could be represented by thirteen extracted factors. The first factor extracted by the Varimax Method for Orthogonal Rotation accounted for by factor 1 was 5.89. Seven independent variables correlated at .72 and higher with factor 1. These seven variables were the Brown and Holtzman (1967) study habits and attitudes scales. The following correlations between study skills and factor 1 were observed: DA=.72, WM=.80, SH=.84, TA=.77, EA=.88, SA=.89, SO=.97. All the study habits and attitudes scales, except TA, had been noted to correlate positively with academic achievement. Furthermore, all the SSHA scales but TA and SA had been noted to correlate negatively with the amount of time taken to complete the self-paced course. Each of the linear regression equations adopted for prediction of total achievement, objective and subjective achievement for both sexes, and time spent in instruction had included SSHA variables which explained significant proportions of the variance in those criteria. Therefore, the factor analysis results for factor 1 were interpreted as being indicative of the homogeneity and internal validity of the SSHA scales in relating to measures of academic success in self pacing.

Factor 2 accounted for S^2=4.97, 15.82% of the variance in the factor matrix. This factor was interpreted as being a cognitive skills factor, as only cognitive variables maintained factor loadings greater than .62.

ACT English (.65), ACT Natural Science (.80), ACT Composite (.96), and college GPA (.62) were the independent variables constituting factor 2. All of these variables had been noted to correlate positively with achievement in the course, and negatively with time spent in instruction. This homogeneous group of cognitive variables sharing the variance in factor 2, interestingly, accounted for less of the variability in self-paced success than study skills, factor 1.

The variance attributed to factor 3, s^2=1.95, represented 6.22% of the total variance. The factor loadings for factor 3 were 16PFF (.70), 16PFH (.76), 16PFA (.42), and 16PFE (.40). Each of these variables were negatively correlated with course achievement. The interpretations of those variables, as they related to academic success, were that high achievers could be characterized as being introspective (F), withdrawing and disliking groups (H), aloof, liking to work alone (A), and submissive (E). Therefore, the collective description for factor 3 was interpreted as being personality variables characterizing success at self-pacing.

The three need achievement scales were observed to maintain factor loadings greater than .77 with factor 4. Peer Nach (.79), general Nach (.77), and summed Nach (.96) shared the variance attributed to factor 4, which was 8.33% of the total variance in the matrix. All three of these measures correlated positively with achievement and negatively with time. Factor 4 attested to the homogeneity of the achievement motivation scales and their validity in accounting for variability in self-paced success.

Factor 5 accounted for S^2=2.04 which was 6.49% of the matrix variance. Those variables with heavy factor loadings were age (.89) and total number of semesters attended (.89). Factor five therefore represented demographic variables related to experience.

The variance attributed to factor 6 was S^2=2.24. This was 7.12% of the total matrix variance. The 16PF variables Q_2 (.77), Q_3 (.71), A (.58), and C (.52) maintained substantial factor loadings with factor 6. The directions of the relationships these variables held with self-paced achievement, and therefore, the variable interpretations suggested that factor 6 be interpreted as personality variables relating to independence.

Factor 7 accounted for S^2=2.13, which was 6.78% of the total variance. Personality variables 16PFI and 16PFM loaded with factor 7 at .74 and .65,

respectively. The interpretation of these personality variables, which correlated positively with achievement and negatively with time, was that collectively they characterized sensitive students who were generally not amenable to group activity.

Factor 8 accounted for 4.99% of the total variance. The dependent variable time correlated with factor 8 at .80.

Factor 9 accounted for 7.00% of the total variance. Personality factor O (.73) and 16PFQ4 (.76) were highly correlated with factor 9. Both variables were negatively related to achievement, and were interpreted as indicating that stable, secure students were more likely to achieve than tense, insecure students.

The only variable which related to factor 10 was the number of credit hours taken, with a factor loading of .71. The number of hours taken during the semester was significantly negatively correlated with the amount of time a student spent in instruction. Factor 10 accounted for 4.8% of the matrix variance.

Factor 11 accounted for 4.34% of the total variance. Personality factor Q1 was the only variable maintaining a high factor loading with factor 11 (.82). On the basis of this finding, factor 11 was considered to represent conservatism, which was positively related to course achievement.

Total points in the course was the only variable related to factor 12, at .70. Factor 12 accounted for 5.02% of the total variance.

Factor 13, which accounted for 4.35% of the variance, was related to 16PFB and 16PFN. The interpretation of the relationship of these two variables with success in the course was that both personality measures represented sophistication and intelligence, which resulted in high achievement.

Factor	Interpretation	Variance	Percent
1	Study skills	5.89371	18.76
2	Cognitive skills	4.97191	15.82
3	Personality variables, internality	1.95533	6.22
4	Achievement motivation	2.61768	8.33
5	Demographic, experience variables	2.03813	6.49
6	Personality variables, independence	2.23651	7.12
7	Personality variables, sensitivity	2.12910	6.78
8	Time	1.56768	4.99
9	Personality variables, stable, secure	2.19827	7.00
10	Hours taken	1.50781	4.80
11	Personality variables, conservative	1.36420	4.34
12	Achievement points	1.57602	5.02
13	Personality variables, sophistication and intelligence	1.36610	4.35

CONCLUSIONS AND DISCUSSION

The Relative Contributions of Cognitive and Affective Variables Accounting for Variance in Achievement and Time Spent in Instruction in the Self-Paced Course

Stepwise multiple regressions for the dependent variables, achievement and the amount of time in days taken to complete the self-paced course, were utilized for the judicious selection of independent variables accounting for significant proportions of the variances in those criteria. Variables which made significant relative contributions to explaining individual differences in self-paced achievement and the amount of time it took to complete the course were then included in linear multiple regression equations intended to predict achievement and time in subsequent samples of students. Aside from the predictive function of the linear regression equations for the best-fitting lines representing the dependent variables, the linear equations were also intended to explicate the relative contributions of cognitive and affective individual differences functionally related to individual differences in achievement and time spent in instruction. Because the linear regression equations were constructed in standardized form, with standardized regression weights and standardized z scores for the predictors and the criteria, the different independent variables accounting for variability in the dependent measures were comparable in terms of unit of measurement, and the regression weights, or beta weights, could be interpreted as representing the relative contributions of those independent variables in predicting the criteria. Given this statistical rationale, stepwise regressions for the dependent measures on the 38 cognitive and affective independent variables employed in the study were computed. The most efficient regression models, those that accounted for the largest proportion of explainable variance in the criteria, while employing independent variables which could independently or in combination with other predictors account for significant proportions of the variance in the criteria with $\alpha = .05$, were then selected for predictive purposes.

Also, a principle-components factor analysis was computed to assist in understanding the relationships among variables accounting for variance

in academic success in self-paced instruction. The factor analysis was employed as a subjective validational procedure for defining classes of variables relating to self-pacing success. Primarily, this procedure stratified the variety of affective, cognitive, and demographic variables into meaningful clusters.

The results of the stepwise regressions for total achievement in the course indicated that a six-variable model accounting for 57% of the variability in that criterion, for students in the normative sample, represented the most reliable account of explainable variability. This model included the cognitive variables, college GPA, ACT composite, and ACT english. Also, the study skills variables, SSHA-SA and SSHA-SO, and personality factor Q2 were included in the model. In combination, each of these variables could account for a significant proportion of the variance in total achievement. The values for the standardized beta weights for these variables indicated that in terms of relative contributions in explaining individual differences in self-paced achievement, the affective study skills variables were most important. The fact that study skills made a greater contribution to explaining achievement, relative to college GPA, suggested that, as expected, the skills essential to academic success in self-pacing were different than those traditionally related to academic success in more conventional courses. The fact that study skills could account for more variability in self-paced academic success than cognitive factors was duplicated by the factor analysis, which indicated that factor 1, which accounted for 19% of the matrix variance, was defined by SSHA dimensions. Following study skills in relative importance for explaining individual differences in achievement were the cognitive variables, college GPA, ACT composite, and ACT english. The factor analysis supported this finding, as factor 2, representing 16% of the matrix variance, was attributed to cognitive skills. Lastly, 16PF factor Q2, defined as "self-sufficiency" was an affective variable which made a significant contribution to explaining the variability in self-paced achievement. Students who were self-sufficient got higher grades in self-paced instruction., relative to students characterized as being dependent on groups and who got lower grades.

The stepwise regressions for the amount of time students took to complete the self-instructional course on the 38 independent variables

revealed that only 53% of the variance in that criterion could be explained. The unexplained variance was for statistical purposes interpreted as standard error, or residual error. For practical purposes, this unexplained variance was interpreted as indicating that inappropriate predictors of time had been employed, or, that the predictors employed maintained non-linear relationships with that criterion. These same 38 predictors could account for 72% of the variance in achievement in a linear model. The heterogeneity of the predictors suggests that if time represents a measure of academic succuss, then these predictors should tap that variable. Therefore, the most likely explanation for unaccounted for variance in time appears to be that these kinds of predictors were related in a non-linear fashion.

The most efficient model in terms of reliability and the number of variables employed in estimating the amount of time a student spent to complete the course, was a five-variable model which accounted for 30% of the variability in that criterion. Those five variables ranked according to their relative importance in contributing to the line of best fit for time, that is according to the magnitude of their beta weights, were college grade point average, 16PF factor Q3, 16PF factor A, 16PF factor E, and locus of control. In interpreting the meanings of these variables as they related to time, it is important to note that the time taken to complete the course was inversely related to the level of achievement attained. Students who got higher grades did so in less time than students who got poorer grades. Consequently, college GPA was negatively weighted in the regression equation for time. Students who took a long time to complete the course, which was related to poorer achievement, were noted to score low on 16PF factor Q3, and could be described as "lacking in will control and are not conscientious". Students who completed the course in less time were self-controlled on the basis of 16PFQ3. Factor A was significantly correlated with time in a positive direction. Students who were sociable and easy-going spent more time in instruction than students who finished in less time and were described as aloof and liking to work alone. Students who scored low on factor E and were characterized as being submissive, followers, and liking to work in groups, took the longest time in instruction. Locus of control was negatively correlated with time. This meant that internally-oriented students spent longer than externally-

oriented students to complete the course. Since more time was related to less achievement, this locus of control result was incongruent with previous research findings. However, the interpretations of 16PFQ3, 16PFA, and 16PFE were psychologically consistent. Locus of control did correlate negatively with these three personality variables, though, and its contribution in explaining time may have been due to its moderating effect on these variables rather than its direct influence on time.

Those predictors for the amount of time a student spent to complete the course described successful self-pacers as those students who completed the course quickly. They were generally better students in terms of cognitive skills, and they exhibited personality characteristics congruent with successful self-instructional skills. These same personality characteristics would not necessarily be an asset in conventional group-based instruction. It is interesting to note that the most efficient model explaining variance in time in the cross-validational sample included only affective variables.

The Relative Contributions of Cognitive and Affective Variables Accounting for Variance in Norm-Referenced and Criterion-Referenced Conditions

Even though this self-instructional course was not criterion-referenced in the sense that students were expected to achieve to a specified level of mastery, 77% of the course's total achievement points were for objective, criterion-referenced tests. Students took the objectively scored achievement tests when they felt prepared to do so. They were given immediate knowledge of their test results, which could be interpreted as representing different levels of achievement. These achievement levels had been established in reference to the total number of possible points in the course and rigorous cut-off points for letter grades in the course. Therefore, when a student took a test, he knew how high he would have to score in order to earn an established letter grade at the end of the course. If the student was not satisfied with his level of achievement on a test, two test re-takes were available to improve that test score. In this sense, the objective tests were referenced to a criterion.

Self-paced achievement scores, other than for objective tests, were considered to be norm-referenced. That is, students' scores on

written assignments were awarded in reference to their performance relative to their peers. Course points awarded for discussion group attendance were subject to subjective scoring systems too. Therefore, a distinction was made between achievement based on objective, criterion-referenced conditions and achievement based on subjective, norm-referenced conditions within the self-paced course. The assumption was made that achievement in most college courses is norm referenced. That is, in most college courses, students' achievement is relative to their standing among peers. To determine if students' individual differences were differentially rewarded under criterion-referenced and norm-referenced conditions, stepwise multiple regressions, to discern the relative contributions of variables accounting for variance in self-paced objective and subjective achievement and in general college achievement (GPA), were computed.

The linear stepwise multiple regressions for objective points in the self-paced course on the independent variables indicated that college grade point average alone accounted for 40% of the variance in that criterion. In a nine-variable model for objective points, R_2=.58, cognitive skills were noted to make the greatest relative contributions to variability in the criterion. College GPA, ACT composite, and ACT english were the significant congitive predictors in this analysis. Students' study skills, SSHA-TA and SSHA-SO, made the second largest contribution to explaining objective achievement variance. Personality factors, 16PFQ3 (self-sufficiency) and 16PFQ4 (stability), made significant contributions to explaining variability as well. The regression analyses for criterion-referenced achievement in the self-paced course suggested sex of the student to be a relevant variable. Therefore, multiple regressions for objective achievement were computed separately, stratified by sex. The relative contributions of cognitive and affective variables accounting for females' objective achievement variance were similar to the findings for both sexes together. In the regressions for male students, cognitive variables were slightly less significant than for females, and achievement motivation and personality variables made greater relative contributions to the explainable variance than for females.

It was interesting to note that 81% of the variance in females' objective achievement, and 99% of the variance in males' objective

achievement could be explained by the independent variables in this study. In contrast, only 46% of the variance in the subjective achievement of self-paced students could be explained. The Stepwise regression for subjective achievement in the course indicated that the affective variables SSHA Delay Avoidance and 16PF factor H (sociable and participating) represented the most reliable model for explaining variability in that criterion. The addition of college GPA and high school GPA did not significantly improve the predictive equation. In other words, subjective, norm-referenced educational conditions within the self-instructional course rewarded different student characteristics than the criterion-referenced portion of the course. Objective achievement was best explained by cognitive factors, although study skills were important too, and subjective achievement was best explained by affective student characteristics. As pointed out by Holland (1961), different conditions rewarded different kinds of students. The significance of this finding was important for two reasons. If trying to make selective instructional decisions, an issue this study addressed, the composition of the course, in regard to who and what gets reinforced, must be considered. Secondly, if designing a course of instruction, self-paced or otherwise, the reward system utilized should be congruent with the objectives of the course.

College grade point average, assumed to represent norm-referenced achievement, was examined by multiple regression analyses to discern the relative contributions of affective and cognitive variables in explaining that criterion. The independent variables employed in this study accounted for 77% of the variance in college GPA. The most reliable and efficient model explaining individual differences in college GPA included, in order of their relative contributions, high school GPA, ACT composite, the composite measure of achievement motivation, and 16PF factor A. Each of these independent variables made significant contributions to explaining variability in college GPA, both independently and collectively. The fact that high school grade point average and ACT composite accounted for significant proportions of the variance in college GPA was congruent with previous research, and attested to the predictive validity of using those variables for selection of college students. That the Holmes and Tyler (1968) achievement motivation scale ranked with high school GPA and ACT composite scores in the prediction of college GPA

attested to the predictive validity of that scale and to the validity of using self-report techniques to assess what has traditionally been assumed to be a semi-conscious trait. The significant personality factor A was interpreted as meaning that aloof persons who prefer to work alone exhibit higher college achievement than persons who are sociable and like to work in groups. Personality factor A was noted to account for a significant proportion of the variance in achievement in the self-paced course as well.

Criterion-referenced conditions in the self-paced course rewarded students' cognitive skills. Norm-referenced conditions in the course rewarded affective skills. College grade point average represented cognitive and affective individual differences, and was, therefore, considered to be a global representation of academic success specific to neither criterion-referenced conditions nor norm-referenced conditions.

The Utility and Validity of Using Multiple Regression Equations for the Prediction of Academic Success

Using multiple regression analysis to identify individual differences shared by students who are successful or unsuccessful at an academic task is a separate issue from using multiple regressions to construct predictive equations to be employed with subsequent samples. In this study both of these uses of multiple regression analyses were employed. It is important to note that the proportions of the variances of the dependent variables in this study, which were attributed to individual differences in the independent variables for students in the normative sample (N=77), were statistically reliable at the .05 level of confidence. Those variables identified as contributing to variability in self-paced academic success and general success in college (GPA), as well as the relative contributions of those variables in standard score form, represented the most accurate and informative accounts of their relative importance in explaining the criteria within the normative sample as was possible. However, reliability is a necessary but not a sufficient condition for validity. The validity of those multiple regressions for predicting academic success in a self-instructional course was contingent on the reliability of those regression equations across samples or sub-populations. Although the regression equations were reliable and valid for

the sample on which they were founded, their predictive validity was contingent on cross validation with a different group of students. Furthermore, it should be noted that the predictive validity of regression equations is strictly a statistical issue. The utility of those predictive equations is a practical issue. The predictive validity of regression equations is a necessary but not a sufficient condition for their utilitarian value. To make instructional decisions on the basis of regression equations requires their predictive validity and their practical utilitarian worth.

The predictive validity of the multiple linear regression equations adopted for the self-paced criteria, total achievement, objective achievement, subjective achievement, and time taken to completion, was tested by zero-order correlations between the cross validational students' actual scores for a criterion and the students' predicted scores for that criterion (N=43). The product of this computation is termed the cross validation multiple R, or, Rc. If the magnitide of Rc was reasonably close to the magnitide of the multiple R corrected for shrinkage, R', then confidence could be placed in the regression equation's predictive validity.

In this study, the predictive equations developed on the basis of individual differences in the normative sample failed to predict the actual criterion scores for students in the cross validational sample within tolerable limits. This disappointing discovery negated the use of the linear equations for predictive purposes. The possible explanations for this failure to demonstrate predictive validity were heterogeneity of the two samples, and the uncritical selection of independent variables for inclusion into the regression equations. These issues will be addressed separately.

Because the cross validational sample was selected entirely at random from the total relevant population, the heterogeneity of the two samples was unlikely. However, tests for the homogeneity of related variances for each variable in the two samples were conducted. The findings of these computations supported the homogeneity of samples. However, the test for homogeneity of related variances is a univariate test. The linear equations are multivariate. To test the assumption of equal variances for all conditional distributions of the predicted criterion

is a laborious task. In fact, the task is rarely attempted, and the assumption of equal variances for all variables in a multivariate normal distribution is generally made without being tested. While this possibility could explain the lack of predictive validity, random assignment of subjects suggests otherwise.

The second possible explanation for the lack of predictive validity was the uncritical selection of variables for inclusion into predictive equations. This possibility assumes two forms. First, the .05 level of confidence employed for inclusion of variables into predictive equations was not rigorous enough to produce reliable results. However, increasing the level of confidence would decrease the number of predictors and thereby decrease R^2, the proportion of explained variance. Therefore, this self-defeating procedure was eliminated as a possible explanation of poor predictive validity. What seems the most likely way to increase the reliability of predictive equations is to use a normative sample of sufficient size. The sample size for construction of predictive equations in this study (77) was, therefore, concluded to be inadequate to justify predictive validity.

The regression equations constructed on the basis of individual differences in the normative sample were intended for probabilistic use in a Z score equation, provided they had been reliably cross validated on the second sample. This probabilistic use of regression equations, although not discovered in the reviewed literature, was ideally suited for use in mastery learning strategies. By establishing an achievement criterion, or mastery level, and then employing the regression equation to predict a student's achievement, one could ascertain the probability of that student, with those given personal characteristics, actually attaining the mastery level. Provided that the collection of independent variable information was practical and did not impose on personal freedoms, and that those variables could be reliably included in valid prediction equations, the probability of a student reaching an established criterion within specified time limits could be established. While this probability statement would not likely be used to screen students on an all or nothing basis, as college admittance offices do, the statement could be used to make practical recommendations to the student concerning the kind of

instruction most suited to his or her individual characteristics. If instructional options were available, then recommendations of this nature could be of real value to the student. Furthermore, since instructional strategies such as the mastery strategy have been noted to result in a disproportionately large number of students with incomplete grades, which translates into more administrative time and money, recommendations by probability of success models could be of real administrative value.

Individual differences have not vanished as yet because of excellent instruction. Individually prescribed instruction, based on the premise of individual differences, provides a feasible option to equalize instructional outcome without equalizing students.

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